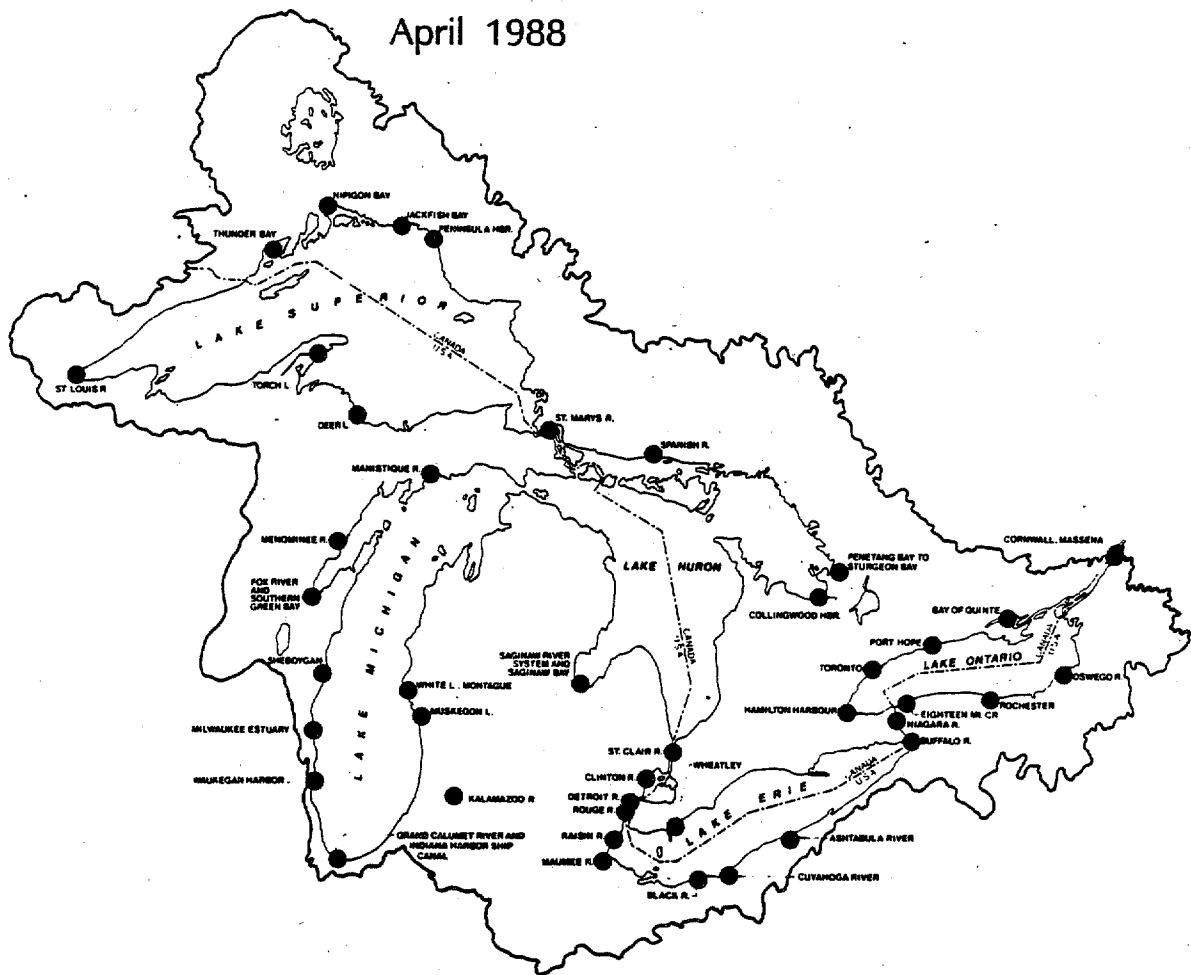


NOAA Involvement in the Great Lakes

April 1988



U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

NOAA Estuarine Programs Office

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NOAA Estuarine Programs Office
Virginia K. Tippie, Director

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INTRODUCTION

Estuaries are among the most productive of natural systems, providing the Nation with a rich variety of goods and services. They are important features of the Nation's coastal regions, especially along the Atlantic Coast and Gulf of Mexico. They represent a transition zone between freshwater and marine ecosystems. They are most commonly defined as semi-enclosed coastal bodies of water having a free connection with the open sea and within which seawater is measureably diluted with freshwater from land drainage.

Although the definition of an estuary does not strictly apply to the waters and shorelines of the Great Lakes, the bays and marshes within this system serve many of the same functions as similar areas in coastal regions. For this reason, NOAA and the NOAA Estuarine Programs Office are involved in the search for solutions to the many problems facing these inland freshwater seas and their fragile and vulnerable wetlands resources. These concerns are defined in the NOAA Estuarine and Coastal Ocean Science Framework (October, 1987).

OVERVIEW

Some 8,000 miles in length, the Great Lakes' coastline forms an aquatic ecosystem which rivals in size and complexity the continent's Atlantic, Pacific, Gulf, and Arctic shores. Covering 95,000 square miles, the lakes contain one-fifth of all the fresh water on earth. With outflow restricted by narrow connecting channels, the lakes form an almost completely closed system. For example, it takes Lake Superior 180 years to turn over its entire volume of water. Shallow Lake Erie, with only three years' replacement time is easier to pollute but responds more quickly to clean-up efforts. A profile of the Lakes appears below:

LAKE

| | Superior | Huron | Michigan | Erie | Ontario |
|------------------------------|----------|--------|----------|-------|---------|
| Surface area square miles | 31,700 | 23,000 | 22,300 | 9,910 | 7,340 |
| Average depth feet | 483 | 195 | 279 | 62 | 283 |
| Volume cubic miles | 2,900 | 850 | 1,180 | 116 | 393 |
| Replacement time years | 180 | 25 | 70 | 3 | 8 |

Source, National Geographic July, 1987

The problems facing those who would manage this great expanse of water were summed up recently by T. M. McMillian, Minister of the Environment (Canada):

"The Great Lakes are a magnificent and priceless resource shared by two of the world's most fortunate countries. It is the largest freshwater surface on earth containing approximately eighteen percent of the world's supply; the surrounding region is home to one-quarter of Canada's population (thirteen percent of the United States' population) and is an important element of the physical and cultural heritage of North America.

The Lakes are a mystery. Time and again, they reject all attempts at an adequate portrayal. Despite their mammoth size, they are vulnerable to the assaults of pollution. Their calm exterior belies the terrible destructive force of which they are capable.

Understanding and managing the Great Lakes are difficult tasks. While most of the attention given to them over the past 15 to 20 years has focused on the question of water quality, the quantity of water in the upper lakes system is also a serious concern. Above average precipitation, compounded by storm surges, has pushed water levels to record highs for all lakes except Lake Ontario. The resultant flooding, soil erosion, and property damage have wreaked havoc throughout the area. On 1 August, 1986, the governments of Canada and the United States instructed the International Joint Commission (IJC) to examine the report on methods to alleviate such adverse effects in the Great Lakes-St. Lawrence River Basin. It is one of the most wide-ranging and important references ever given to the Commission. The study will address, among other topics, land use, climate change, and water quality within the basin. (The Great Lakes United, Summer, 1987)."

NOAA ORGANIZATION

The National Oceanic and Atmospheric Administration (NOAA) is structured as indicated in Figure 1. The five Line Offices of NOAA, listed at the bottom of the diagram, represent the managerial and research functions of the agency. These Line Organizations are:

- National Ocean Service
- National Weather Service
- National Marine Fisheries Service
- National Environmental Satellite, Data,
and Information Service
- Office of Oceanic and Atmospheric Research

As can be seen from the titles alone, each of these groups has an expertise which can be applied to problems and management questions facing the Great Lakes system. Although NOAA's primary concerns center in our estuaries, coastal seas, and continental shelf waters, there is a NOAA presence in the Great Lakes which involves everything from Sea Grant Research Programs to ice prediction using satellite imagery.

In order to make this presentation more meaningful, the role of each Line Office will be described separately. Before beginning this discussion, however, the NOAA Estuarine Programs Office should be mentioned. This group is part of the Office of the NOAA Chief Scientist and was formed to coordinate NOAA's estuarine activities throughout the country. This document represents part of this coordination function as it serves to describe, in one place, NOAA's Great Lakes programs.

THE NATIONAL OCEAN SERVICE

The National Ocean Service (NOS) has the responsibility of updating and producing nautical charts for all United States waters. This task extends to the Great Lakes where, in cooperation with Canadian authorities, charting activities are carried out. These surveys involve the use of the NOAA Fleet and Hydrographic Field Parties. The Charting and Geodetic Services Office within NOS is also responsible for maintaining the national geodetic grid into which all state and local surveyors must tie when determining various land boundaries and object positions.

The Office of Oceanography and Marine Assessment (OMA), within NOS, is responsible for collecting water level data for the entire Great Lakes basin watershed (295,000 square miles), and for maintaining the International Great Lakes Datum of 1955 (IGLD 1955). In meeting these responsibilities, close coordination is maintained with other Federal Agencies and Canadian counterparts. Exchanges of water level data with Canada are made under treaties that require regulation of operations and support of cooperative power generation. These exchanges are coordinated under the International Joint Commission (IJC), a group of six commissioners appointed by the President of the United States and the Prime Minister of Canada. Parties involved in meeting the international agreement include: several boards of control, IJC committees of two Federal Agencies, eight states and two Canadian Provinces.

Beginning in 1970 (under authority of Presidential Reorganization Plan #4, now part of U.S. Code 33, Title 883), OMA's predecessor organization began a program of monitoring and collecting water levels, and maintaining a vertical control reference system for the Great Lakes and their connecting channels. The program, required by Congress and by international treaties, has a mission of providing a hydraulic vertical reference datum by which the governments of Canada and the United States manage water resources in the Great Lakes basin. International management of water resources in the Great Lakes basin is vital to ensuring the safety of the Lakes' many users. The Great Lakes Program takes into account fluctuations of the Lakes' water levels and outflows of rivers relative to: regulation, lake level forecasting, shipping, international hydroelectric power generation, construction, dredging, litigation, and other water resource management and development activities.

Currently, the Great Lakes Program is divided into office and field functions to address: basic water level measurements, vertical datums, earth movement (for the International Great Lakes Datum), basin precipitation, abstracts of diversions, vertical control support for hydrographic surveys, construction and maintenance activities, and needs of user communities. Since 1973, OMA has provided real-time data for emergency water planning situations by using water level gauges with electronic telemetry units. Now, 24 water level measurement units are operating in the field; OMA plans to operate 50 field units by 1991 through the use of improved, state-of-the-art electronic telemetry systems.

Permanent water level measurement stations are located in eight Great Lakes states as follows:

| | | |
|--------------|----|-----------------------------------|
| New York | 12 | Stations of which 4 are telemetry |
| Pennsylvania | 1 | " " " 0 " " |
| Ohio | 4 | " " " 3 " " |
| Michigan | 28 | " " " 12 " " |
| Minnesota | 3 | " " " 2 " " |
| Wisconsin | 4 | " " " 2 " " |
| Illinois | 1 | " " " 1 " " |
| Indiana | | No measurement stations operated |

Additionally, NOAA operates six tidal observation stations in New York and one tidal observation station in Pennsylvania. These stations are not physically located within the Great Lakes drainage basin.

The Office of Ocean and Coastal Resource Management (OCRM)

Four Great Lakes states are participating in the Federal Coastal Zone Management System: Michigan, New York, Pennsylvania, and Wisconsin. Of the four non-participating states, Ohio and Minnesota are developing state coastal zone management programs. In Ohio, the Governor recently set up the Lake Erie Office to develop a state coastal management program and to coordinate Lake Erie programs and policies. In Minnesota, the Department of Natural Resources is funding the North Shore Management Board to develop a North Shore Management Plan.

The Pennsylvania Coastal Zone Management Program, approved in 1980, encompasses 63 miles of Lake Erie shoreline. Since 1980, Pennsylvania has spent about \$2,049,000.00 on coastal zone management in the Lake Erie Coastal Zone. Recent activities include developing a comprehensive waterfront plan for the City of Erie, funding waterfront redevelopment projects, providing public access and boating facilities at several locations, and providing technical assistance to property owners and local governments concerning high lake levels.

Approved in 1978, the Michigan Coastal Zone Management Program (MCZMP) covers 3,200 miles of shoreline on Lake Michigan, Lake Huron, and Lake Superior. The State has received about \$2,000,000.00 in Federal funding for each of the last three years, with a total amount of \$16,032,000.00 in Section 306 funds since 1978. Since 1974, OCRM has spent a total of \$19,200,000.00 on coastal zone management in Michigan. The Michigan Coastal Zone Management Program has funded a large number of low-cost construction projects (Section 306). Examples of 306A projects include interpretive displays, historic preservation, public access and park improvements. In addition, the State uses funds to administer Shorelines Protection and Management Act, the Great Lakes Submerged Lands Act, and the Sand Dune Protection and Management Act. The MCZMP continues to develop the Great Lakes Information System, a computerized geographical information system.

The Wisconsin Coastal Management Program (WCMP) was approved in 1978; it encompasses 820 miles of shoreline on Lake Michigan and Lake Superior. The WCMP received a total of \$9,457,000.00 in Section 306 funds during the period 1978-1987. The State has received between \$869,000.00 for each of the last three years. Since 1974, OCRM has spend a total of \$12,169,000.00 on coastal zone management in Wisconsin. The Wisconsin Coastal Management Program targets several policy and program areas each year. Recently, the WCMP has focused on developing regulations for the disposal of dredged material, improving waterfront redevelopment, and improving the management of shoreline erosion and flooding areas.

The New York Coastal Program (NYCP), approved in August, 1980, covers 1,049 miles of shoreline on Lake Ontario and Lake Erie. The NYCP has spent about \$500,000.00 per year for the last three years on the Great Lakes portion of the program. The funds are divided between general program administration, development and implementation of local waterfront revitalization plans, low-cost construction projects, and the mapping of erosion rates.

National Estuarine Research Reserve System (NERRS)

This program operates under Section 315 of the Coastal Zone Management Act of 1972 (Public Law 92-583) as amended, which authorizes the Secretary of Commerce to make financial assistance awards to coastal states for up to 50 percent of the cost of acquisition of wetlands and uplands surrounding the estuary and for the development of associated research and educational programs. Sanctuaries are representative of the Nation's various ecosystem types. The National Estuarine Research Reserve System (NERRS) protects thousands of acres of estuarine waters, marshes, and shorelines. The goal of NERRS is to establish and manage a system of Reserves representing different coastal regions and estuarine types that exist in the United States and its territories. Of the 17 designated Reserves, Old Woman Creek, located on Ohio's Lake Erie Coast, is the only Great Lakes-type estuary in the Program.

This 561 acre Reserve serves as a field laboratory where scientists can study naturally functioning systems and where students and the general public can learn about estuarine ecology in a natural setting. The Reserve encompasses a variety of habitats including freshwater marshes, swamp forests, barrier sand beach, upland forests, open waters of the estuary, stream, and nearshore Lake Erie.

Research on coastal saltwater estuaries has demonstrated the importance of these wetlands in providing many natural and cultural benefits. The objective of studies undertaken at Old Woman Creek is to determine the extent that freshwater Great Lakes-type estuaries and coastal marshes perform similar functions. Research at Old Woman Creek is directed toward analyzing ecological relationships within this Great Lakes environment and documenting existing environmental conditions within the Reserve and monitoring changes as they occur. Studies comparing this relatively unmanipulated natural system to similar areas that have been affected by human activity are also encouraged.

The objective of the Old Woman Creek educational program is to provide a focus for increasing public awareness and appreciation of Great Lakes coastal wetlands, as well as to disseminate the results of research to legislators and other coastal decision-makers. The format chosen to facilitate this exchange of information concentrates on topics directly related to estuaries and other coastal wetlands of the Great Lakes. Programs range from illustrated slide talks and development of estuarine ecology curricula for schools to college-credit workshops for students and teachers, and a lecture series open to the general public.

THE NATIONAL WEATHER SERVICE

The National Weather Service (NWS) is one of the best known of NOAA's Line Offices. Because NWS forecasts the weather, a factor that affects our daily lives, the work carried out by this "LO" results in products which can be read in daily newspapers, watched on television, or heard on the radio. The National Weather Service (NWS) responsibilities in the Great Lakes are in the form of routine forecasts and warnings, training of ship crews to perform and record weather observations, the receipt and analysis of these observations from lake vessels, and the maintenance of shipboard observation equipment.

The Great Lakes are home to some of the most severe weather in the country. Those who live in other parts of the country are well aware of the violent winter storms which can threaten shipping and endanger life and property. Because of their variations in depth, strong winds cause different problems in different lakes. In deeper water, large waves and shore erosion result. In shallower areas, such as Lake Erie, storm driven oscillations within the basin (called a "seiche") can reduce the water depth in western Lake Erie to the point at which ships must be immediately notified of the conditions.

NWS is involved in all these predictions and is currently working with other parts of NOAA to upgrade their equipment and increase the applicability and timeliness of their forecasts. These efforts include a 25-year storms statistic study, a Forecasters Handbook, and increased training for observers. Hardware to support this program will comprise Shipboard Environmental (data) Acquisition Systems (SEAS), expendable bathythermograph probes, real-time water level data, a new generation of water level gauges. The development of a dynamic wave prediction model, wind field model, and a coupled wind/wave model are also underway at this time. NWS will also use improved satellite techniques to predict ice conditions within the Great Lakes basin.

Because of recent high water levels in the Great Lakes new, special forecasts have been issued daily for expected water levels as the result of wind buildup. These forecasts are significant to coastal flooding and erosion interests. Another special problem is winter ice that builds up at the mouths of rivers entering the Lakes. Under extreme conditions, ice dams develop causing local flooding upriver. These conditions are now monitored and a cooperative program with the Corps of Engineers acts to clear the ice when forecasts call for such buildups. NWS cooperates with the Sea Grant Program to augment marine weather observations by trying to increase the number of observations in the near shore (<5 mile) area. Of interest here are winds, wave heights, water temperature, visibility, and present weather. Specialized forecasts are also prepared for other water interests such as sailing and power boat races, yacht clubs, and boating safety training. Centralized forecast offices for the Great Lakes region are located in:

Ann Arbor, Michigan
Chicago, Illinois
Cleveland, Ohio
Buffalo, New York

THE NATIONAL MARINE FISHERIES SERVICE

As the title indicates, the National Marine Fisheries Service (NMFS) plays a major role in the Nation's estuaries, coastal seas, and continental shelf waters. For this reason, NMFS has a limited presence in the Great Lakes region and their Great Lakes program is the responsibility of the Northeast Regional Fisheries Office in Gloucester, Massachusetts.

Fisheries program activities in the Great Lakes include:

1. Grants programs - NMFS administers, through its Northeast Regional Office, three grant programs: the Commercial Fisheries Research and Development act (which expired in October, 1987 and was replaced with a substitute grant program; the Inter-jurisdictional Fisheries Act); the Anadromous Fish Conservation Act; and the Saltonstall-Kennedy Fisheries Research and Development Program. Anadromous Grant Program activities are coordinated with the Fish and Wildlife Service of the Department of the Interior.
2. Fishery products inspection - NMFS provides fishery products inspection services on a fee basis to private firms.
3. Great Lakes Fishery Commission - NMFS serves as an advisor to the Great Lakes Fishery Commission.
4. General liaison - the Northeast Regional Office has established a formal liaison function for the Great Lakes activities, particularly to coordinate agency activities with Sea Grant. The liaison officer is located at the NMFS Laboratory in Oxford, Maryland.

THE NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE

The National Environmental Satellite, Data, and Information Service (NESDIS) contributes many products and services to the Great Lakes region. This involvement can be described as follows, using the various offices within the NESDIS structure as reference points.

The National Oceanographic Data Center (NODC)

NODC receives data each month from the NOAA Data Buoy Center for the eight environmental data buoys located in the Great Lakes. Parameters measured are: barometric pressure, wind speed, wind direction, wind gusts, air temperature, significant wave height, wave spectra, and sea surface temperature. These data cover the time interval from 1979 to the present. In addition, NODC archives GEOSAT altimeter (winds, waves, water height) data. Some data for the Great Lakes are available. The coverage is limited because of the closeness of the land areas; however, some useful information is generated during each 34 day satellite cycle.

The Ocean Pollution Data and Information Network (OPDIN)

OPDIN markets and disseminates the publication, "Inventory of Non-Federal Funded Marine Pollution Research Development and Monitoring Activities - Great Lakes Region" (May, 1985). This office creates and periodically revises, markets, and disseminates the publication, "Handbook of Federal Systems and Services for Marine Pollution Information," and provides searches of large automated data bases containing extensive records of Federal Agency "grey literature" concerning national marine pollution activities.

Assessment and Information Services (AISC)

AISC prepares monthly assessments of temperature and precipitation impacts for the Nation. The National Environmental Data Referral Service (NEDRIS), also part of AISC, is an on-line computer catalog of information and environmental data. NEDRES describes holdings from the Great Lakes which include NOAA and non-NOAA activities.

National Geophysical Data Center (NGDC)

NGDC maintains an archive of approximately 3 million bathymetric soundings for the Great Lakes. A bottom sediment data archive of approximately 15,000 samples is maintained and is being used to study the past climate history of the Great Lakes region.

National Snow and Ice Data Center (NSIDC)

NSIDC maintains an archive of Great Lakes ice data from the Great Lakes Environmental Research Laboratory (which will be described later). Data from the Defense Meteorological Satellite Program as well as reports from cooperative observers aboard ship are also collected. Records of ice type and ice age are put into a digital data base which dates from 1955 to the present. In addition to these activities, NSIDC receives ice concentration from the brightness temperatures recorded by the Scanning Multichannel Microwave Radiometer (SMMR) and is involved in an experimental maintenance of GEOSAT land geophysical data records. NSIDC plans to obtain and archive brightness temperatures on a 12.5 km grid from the Special Sensor Microwave/Imagery (SSM/I). The temperatures will be converted to ice concentrations on a daily basis.

The National Climatic Data Center (NCDC)

NCDC maintains an archive of surface marine synoptic data from the Great Lakes which includes information from ships, buoys, and Coast Guard observations (Radar summaries and radar film of radar sites adjacent to the Great Lakes and an archive of cooperative networks of synoptic meteorological data). NCDC also produces a Summary of Synoptic Meteorological Observations (SSMO) for the Great Lakes. This summary includes winds, waves, sea temperature, and an overall climatology which is updated as required.

The Satellite Data Systems Division of NCDC maintains Great Lakes temperature charts that are retrospective charts from the Ocean Products Center and are hard copy charts produced on a daily basis. Archives of GOES data (1976 - Present) and data from the Advanced Very High Resolution Radiometer (AVHRR) are also available from this office. The latter includes data tapes which cover the Great Lakes from the NOAA polar orbiting satellite.

The Office of Satellite Data Processing and Distribution (SDPD)

SDPD generates biweekly water temperature data using the AVHRR Great Lakes information and available buoy observations. The output from this effort is a printer plot. SDPD provides GOES data using 1 km visible imagery to generate ice analysis for the Great Lakes ice season. Data are forwarded to the Navy/NOAA Joint Ice Center and are analyzed from satellite and ship reports. There are also plans within SDPD to develop an objective automated 7 km analysis using a personal computer image processing system.

Office of Research and Application

This office conducts research for sea surface temperatures from AVHRR data over the Great Lakes. Intense inversion over the Lakes results in remotely sensed AVHRR sea surface temperature up to 2 degrees higher than actual sea-truth readings. The solution of this problem is one of the efforts in which this group is involved.

OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH

The Office of Oceanic and Atmospheric Research (OAR) is involved in climatic and atmospheric research, the Sea Grant and other extramural programs, and the Environmental Research Laboratories. OAR's involvement in the Great Lakes basin is reflected in their administration of the Sea Grant Programs and in the programs and investigations carried out by the Great Lakes Environmental Research Laboratory (GLERL)

The Great Lakes Environmental Research Laboratory

The Great Lakes Environmental Research Laboratory (GLERL) was established by the National Oceanic and Atmospheric Administration on April 25, 1974, to provide a focus for NOAA's environmental research on the Great Lakes. GLERL was formed by combining the staff of the International Field Year for the Great Lakes Project Office (IFYGL, Rockville, Maryland), with the Limnology and Computer Divisions of NOAA's Lake Survey Center (Detroit, Michigan). The Laboratory was opened in Ann Arbor, Michigan, in August, 1974.

GLERL's mission statement (1982) is as follows:

"Conducts integrated, interdisciplinary environmental research in support of resource management and environmental services in coastal and estuarine waters with special emphasis on the Great Lakes. The laboratory performs field, analytical, and laboratory investigations to improve understanding and prediction of coastal and estuarine processes and interdependences with the atmosphere, land, and sediments. It places special emphasis on a systems approach to problem-oriented environmental research in order to develop environmental service tools. It provides assistance to resource managers and others in obtaining and applying the information and services developed by the laboratory."

GLERL's research addresses major Great Lakes and national environmental issues, including water quality (toxic chemicals, nutrient overenrichment), water quantity (lake levels, water supply, diversions, consumptive use, management), and physical hazards (waves, storm surges, flooding, and ice). GLERL researchers often engage in team efforts with scientists at universities or with other agencies in the U.S. and Canada. GLERL's products are information and improved technologies and methods. These products are disseminated through a variety of means, including refereed journals, NOAA Technical Series documents, posters and presentations at local, national, and international meetings and public gatherings, and by direct interactions with users. The latter includes national and local governments, international, Federal, state, and private agencies, industry, academia, and the general public.

GLERL is organized into five scientific groups that conduct both basic and applied research on major environmental problems and issues, plus a number of support units that provide technical, operational, and administrative assistance to the scientific staff.

Lake Hydrology Group - This group investigates the hydrologic and hydraulic processes that affect the water supply to, and amount of water in, the Great Lakes; they provide improved methods of forecasting lake levels and for simulating river flows. Research is conducted in order to characterize and increase our understanding of the seasonal ice and snow cover in the Great Lakes basin.

Synthetic Organics and Particle Dynamics Group - This division studies the processes that control the movement and interactions of trace contaminants in the Great Lakes and coastal marine ecosystems; their research increases our understanding of, and leads to an improved ability to predict, the behavior, fate, and effects of contaminants in the natural environment.

Ecosystem and Nutrient Dynamics Group - This group studies the ecological systems of the Great Lakes and coastal marine environments, focusing on factors and processes that affect ecological succession and control the flow of nutrients and biological energy through the food web; they provide and improve the information used by resource managers for making decisions that impact both water quality and living resources.

Physical Limnology and Meteorology Group - This group explores the physical variables that characterize a lake environment and the manner in which those characteristics change with external forces, such as wind, heat exchange, and connecting channel flows; the results of their research help alleviate or reduce the impact of physical hazards and contaminant transport on both the environment and the people who use it.

Environmental Systems Studies Group - The scientists develop models of environmental systems based on the premise that cost-effective management of our natural resources require that we consider the competing human, economic, regulatory, and ecological factors; they use these models to evaluate and compare the probable costs vs. benefits of resource management plans, and to identify alternative plans that optimize the balance between competing demands on the marine environment.

The scientific groups are supported by a network of services which include:

- * a Marine Instrumentation Laboratory, where instruments and systems for hands-on and automated field collection of data are designed, built, and maintained;
- * a Computer Systems Group that maintains GLERL's in-house computer network, that interfaces with off-site mainframe and super computers, and provides related user support to the GLERL staff and others;
- * an Information Services Group that is responsible for providing editorial and publications support to the GLERL staff, distributing GLERL publications, and responding to related information requests;
- * a Library that maintains a research collection tailored to GLERL staff needs and which offers special retrieval services for materials not in existing holdings;
- * the R/V SHENEHON, GLERL's research vessel and primary platform used by GLERL staff for field operations on the lakes; and
- * an Administrative Office that provides personnel, budget, purchasing, and facility information and management.

The GLERL Research Program: An Overview (1987)

GLERL's multidisciplinary research program includes both basic and applied studies and combines experimental, theoretical, and empirical approaches with field, analytical, and laboratory investigations in support of the Ocean and Great Lakes Prediction Research Program of NOAA. It addresses: (1) the need for new and improved simulation and prediction models of ecosystem structure and function, and the effects of stresses and proposed remedial options, and (2) the needs to assess other options while taking systems dynamics and dimensions into account. Two elements of the Ocean and Great Lakes Prediction Research Programs provide the focus for GLERL research: Marine Ecosystems Assessment, and Marine Hazards and Lake Hydrology.

Another major program supported by GLERL is the Upper Great Lakes Connecting Channels Study, which focuses on water quality and ecosystem dynamics in the upper Great Lakes connecting channels. The lead U.S. agency for this study is the Environmental Protection Agency (EPA), but GLERL scientists have significant roles in both the management of the project and the research conducted for it. GLERL support for this project is partially funded by EPA; the rest is provided under both the Marine Ecosystems Assessment and the Marine Hazards and Lake Hydrology elements of the NOAA Program.

Marine Ecosystems Assessment

The Marine Ecosystems Assessment research program at GLERL is designed to: (1) improve our understanding of, and predictions related to, natural marine ecosystems, physical phenomena, and the effect of human-induced stresses on the ecosystem; and (2) help provide a sound scientific basis for management decisions pertinent to marine resources, marine pollution, and environmentally sensitive marine activities. GLERL projects include investigations into the short- and long-term effects of human, agricultural, and industrial wastes on aquatic life and water quality, particularly in the nearshore zone (the area of maximum use and conflict); the structure and function of aquatic ecosystems and the effects of human activities on those ecosystems; the measurement, analysis, and prediction of physical phenomena such as currents, river flows, and air-water-sediment interactions; and sedimentary fluxes and processes, especially sediment-contaminant interactions.

Marine Hazards and Lake Hydrology

Marine Hazards and Lake Hydrology research focuses on: (1) improving prediction of environmental phenomena associated with the National Weather Service (NWS) marine warning and forecasting services and the U.S. Army Corps of Engineers (COE) regulation of Great Lakes water flow; and (2) providing better tools and methods for short- and long-term assessments of water resources of large

lakes. GLERL research in these areas includes field and analytical investigations to develop simulation and prediction models of over-water wind and wind waves, water surface oscillations, storm surges, and flooding; lake ice formation, growth, movement, and break up; hydrological lake levels, water supplies and balance, and flows in the connecting channels. GLERL staff work closely with colleagues at the forecasting and warning service agencies to assure that GLERL products meet the needs of the operations forecasters. Products released to the user community continue to be improved by GLERL researchers, either by fine-tuning, or by the addition of new tools and capabilities.

Upper Great Lakes Connecting Channels Study

The Upper Great Lakes Connecting Channels Study (UGLCCS) is an international (United States - Canada) and interagency multiyear study of water quality and ecosystem dynamics in the upper Great Lakes connecting channels. Study areas include the St. Marys River, the St. Clair River, Lake St. Clair, and the Detroit River; all are designated by the International Joint Commission (IJC) as "Areas of Concern" in which environmental quality is degraded, and beneficial uses of the water and biota are adversely affected. The goals of this study are: (1) to determine the existing environmental condition of the study areas; (2) to identify and quantify the effects of contaminant loading on human and ecosystem uses of the study areas; (3) to determine the adequacy of existing or proposed programs for ensuring or restoring beneficial uses; and (4) to recommend appropriate programs for protecting study areas.

The National Sea Grant Program

The National Sea Grant College Program represents a national, grassroots-based capability which is essential to the future of U.S. marine resources. Sea Grant is dedicated to the national goal of promoting the understanding, development, utilization, and conservation of ocean and coastal resources through university-based research, education, and advisory services. The program is administered through NOAA's Office of Oceanic and Atmospheric Research (OAR). Of particular interest to this presentation is the Great Lakes Sea Grant Regional Network.

The Great Lakes Sea Grant Regional Network includes programs in New York, Ohio, Michigan, Wisconsin, Minnesota, and Illinois-Indiana. A common aim of these programs is to foster wise use of the natural resources of the Great Lakes. To this end, Sea Grant's efforts in the Great Lakes encompass a wide array of resource needs and topics, including water quality and contaminant issues, restoration of Great Lakes fisheries, aquaculture, economic development, and marine engineering. Examples of the projects undertaken by members of the Sea Grant Regional Network are listed below:

The Illinois-Indiana Sea Grant Program has been instrumental in developing the charterboat industry in this bi-state region. Efforts undertaken include publication of a directory of all licensed boat charter and livery services in these two states; institution of a MAREP (Marine Reporting Program) system with the National Weather Service to provide timely weather forecasts for fishermen; and development of a salmonid diet study which will be used by managers charged with the maintenance and utilization of the fisheries resources of Lake Michigan.

The Michigan Sea Grant College Program recently has been involved in cold water near-drowning research. Hundreds of lives have been saved worldwide as a result of Sea Grant research and education on cold water near-drowning and revival techniques. The research involved in this study demonstrated that people submerged for more than 4 minutes, especially in cold water, could survive with little or no after effects. In fact, victims immersed for as much as an hour have been saved and fully revived as a result of this highly important program.

An extensive outreach program was implemented to disseminate the results of the Michigan Sea Grant research. In Michigan, this involved Sea Grant field agents working together with members of the Coast Guard and the Michigan State Police. First responders (firemen, police, sheriffs, and water rescue personnel) were educated in the use of the newly developed techniques along with emergency room personnel. As a result of this program, the Coast Guard estimates a 25 percent reduction in drowning fatalities currently and a projected reduction of another 25 percent as training continues. As a result of these similar outreach efforts by other elements of the Sea Grant Regional Network, these techniques for reviving drowning victims have become standard throughout the country.

The Minnesota Sea Grant Program is conducting a broad research, education, and extension program addressing issues and opportunities in its Great Lakes region. Aquaculture programs range from fundamental research to extension workshops and publication efforts. Basic studies on the cryopreservation of fish sperm have shown that sperm can be preserved successfully at -320 F. Genetic engineering is being applied to the lake trout. Research is underway to develop techniques for the successful insertion of growth hormone genes into the trout and then to evaluate the growth and fitness parameters of resulting transgenic fish.

Of major concern has been the presence and fate of toxic chemicals in Lake Superior. An extensive research program has found that, in this most pristine of the Great Lakes, almost all inputs of toxic substances such as PCBs are through the atmosphere. PCBs enter the Lake during intense precipitation events, and then are released back into the atmosphere by volatilization at the lake

surface. Decreasing atmospheric and water column inputs suggest the Lake now is a source of PCBs to the atmosphere. Removal of PCBs from the lake by volatilization and sedimentation is relatively efficient, taking between 2-6 years.

The Minnesota Sea Grant Program has an active extension component, with agents and specialists addressing problems and opportunities in aquaculture, coastal erosion, water quality, recreation and tourism, and marine education. Of particular note is an educational program to provide scholarships for study in the marine sciences for American Indians.

The New York Sea Grant Program has introduced the Pacific salmon population in Lake Ontario with great success. The New York Sea Grant Program, through research and extension, has helped communities and businesses along the Lake to respond by developing a major sport fishery. This fishery has become an important economic asset -- \$100 million, annually. New York Sea Grant Program research efforts led to an improved understanding of salmon distribution. This information fostered the development of a viable charterboat industry. Five years ago, there were no charterboats operating in Lake Ontario, today there are 500.

Ash and scrubber wastes produced by electrical generating plants burning coal are a major disposal problem. The idea of combining these wastes and compressing them into solid blocks was presented to Sea Grant. It was found that, although the blocks contain toxic materials, they do not leach these to the marine or freshwater environment and so can be used safely for various purposes; one of these is the construction of artificial reefs. One mid-west utility is now building a coal-waste block reef in Lake Michigan.

The Ohio Sea Grant Program has also been active in artificial reef applications. Lake Erie is the shallowest, most organically enriched, and most biologically productive of the Great Lakes. It produces more fish, annually, for human consumption than the other four Great Lakes combined. Between 1976 and 1984, the number of walleye harvest in Lake Erie increased from 111,000 to 3,000,000 and the number of charterboats increased from 34 to over 600. Most of this fishery production, harvest and recreational development is associated with the western basin of the lake with its many natural reefs. These provide natural habitats and spawning sites for many of the lake's most desired sport species.

The Ohio Sea Grant Program has worked with the U.S. Army Corps of Engineers and the Ohio Department of Natural Resources to develop and implement an artificial reef program in the central basin of Lake Erie. Using materials that were often donated by coastal communities, the program has established reefs that have improved recreational fishing in the area and have provided an opportunity for scientists to test hypotheses regarding the effectiveness of artificial reefs in fishery management.

The Wisconsin Sea Grant College Program is the largest of the six Sea Grant organizations in the Great Lakes area. Major emphases have been placed on studies of pollution dynamics and effects, the relationship of trophic dynamics to fish populations, fisheries management, aquaculture, Great Lakes coastal processes, and diving physiology. A few examples of these interests are provided below.

Understanding the factors that control the distribution and fate of nutrients and toxic organics in the Great Lakes is of major concern to the Wisconsin Sea Grant Program. In this regard, support has been provided for the development of improved chemical analytical techniques and long-term generic studies of the physical chemistry of toxic pollutants, the physico-chemical interactions between toxicants and particulates (living and non-living), and the rate and magnitude of particulate flux in coastal systems. The aim of these efforts is to develop a data base that will permit more accurate predictions of pollutant behavior in Great Lakes ecosystems, using environmental models that currently are available or that are under development.

The Fox River and adjacent Green Bay estuary are the receiving waters for significant quantities of nutrients and toxic substances, including PCBs. This embayment has been identified as one of the International Joint Commission's 42 Great Lakes "hot spots" and is site of a ten-year program of basic and applied contaminant studies by the Wisconsin Sea Grant Program. Much of the resulting information formed the foundation of the recently-completed Remedial Action Plan for the clean up of Green Bay. This was developed under the aegis of the U.S. Environmental Protection Agency. Wisconsin Sea Grant information on Green Bay also was a major factor in the choice of this system as the site for EPA's contaminants "Mass Balance Study."

As a result of pollution, extensive stocking practices, and invasion by exotic species such as the sea lamprey and alewife, the fisheries of Lake Michigan have undergone considerable modification over the past century. As such, the lake forms an ideal laboratory for examining the effects of various human activities on natural systems. Wisconsin Sea Grant scientists, together with their colleagues from other coastal states, have spent considerable effort in examining the relative importance of predation-related ("top-down") vs. nutrient-related ("bottom-up") control of coastal food webs. This line of inquiry also has led to the development of a bioenergetics model as a means for evaluating predator-prey interactions and energy fluxes between trophic levels in the Great Lakes. This model currently is being test-applied to systems around the country, and eventually may become an important tool for fisheries management.

Recent fluctuations in water levels in the Great Lakes and the future of freshwater resources in this largest reservoir in the world, are of major concern to the Wisconsin Sea Grant Program. The high lake levels of the mid-1980s provide an excellent example of the program's response. Extraordinary lake levels produced severe erosion along many portions of the coast, threatening boats, roads, homes, and municipal facilities such as sewage treatment plants. Wisconsin Sea Grant advisory personnel worked with the U.S. Army Corps of Engineers and state agencies to warn of impending dangers and to assist in developing shore-protection strategies. Present efforts are directed at working with relevant public and private agencies (e.g., banks and insurance companies) to build an awareness of the need for erosion protection and appropriate set-backs in siting future developments.

The Benefits of the Sea Grant Program

The Sea Grant concept -- to develop integrated and well-planned competitive research programs, and to follow-up with transfer of information to potential users through education and advisory service -- is unique within NOAA. This approach has been of unquestionable benefit to the Nation as a whole, as well as to the Great Lakes region. Highly effective resource management strategies have resulted in fisheries, water quality and coastal zone management because of Sea Grant activities. In many cases, these lessons have been transferable to marine systems. Sea Grant activities have contributed millions of dollars to the economy of the Great Lakes, and the well-being of life and property have been enhanced. Sea Grant thus is a vital, integral part of the bi-national community of agencies, institutions, and commissions concerned with the wise management and use of the Great Lakes.

SUMMARY

The Great Lakes basin is a large and diverse ecosystem. The lakes share many of the same problems as our northeastern coastal estuarine system which also suffers from the impacts of ever-increasing population pressure, the affects of a century-old industrial complex, and the continued inflow of toxics and undesirable nutrients. For these reasons NOAA maintains a presence in these waters. Many of NOAA's contributions to the well-being of the Great Lakes Community are either very well known (National Weather Service) or, perhaps, virtually unknown. The information contained in this paper was compiled to describe NOAA's involvement on America's "Fourth Coast" and demonstrates how the Nation's ocean and atmosphere agency serves its constituents.

Comments or suggestions may be submitted to:

Commander Carl R. Berman, Jr, NOAA, Ph.D.
NOAA Estuarine Programs Office, CSEP
1825 Connecticut Ave NW Rm. 625
Washington DC 20235

FTS 673-5243
(202) 673-5243

Requests for copies of this document may be addressed to:
Ms. Alice Roberson
Publications Coordinator
at the same address noted above.

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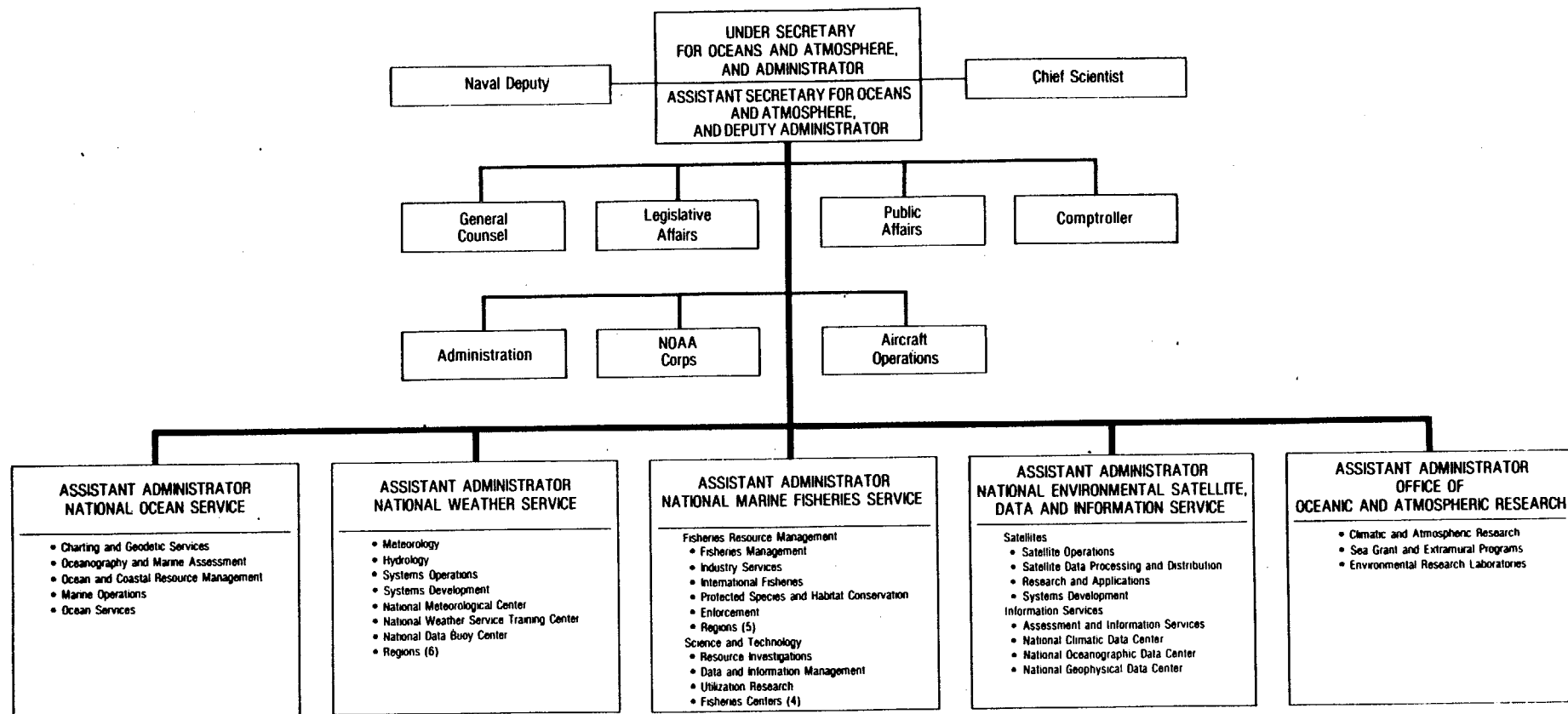


Figure 1 - NOAA Organization Chart